Temporal integration as a funtion of masker bandwidth

(1993)] and multichannel [Mokheimer *et al.*, IEEE Proc. First Intl. Conf. on Electronics Circuits and Systems, Cairo, Egypt (1994)] implementations of the model have been proposed. Time-frequency representations (TFRs) offer a convenient way to process signals over the time-frequency plane. TFRs can be used to compute the IWAIF. TFRs can also be used to compute the short-term IWAIF and the multi-channel IWAIF. These will be presented along with preliminary developments of both the short-term IWAIF and the multichannel IWAIF. The necessary properties of the TFRs to be suitable for use in these models will be discussed. [Work supported by a grant from AFOSR.]

4pPP22. A quantitative prediction of modulation masking with an optimal-detector model. Torsten Dau, Birger Kollmeier (Graduiertenkolleg Psychoakustik, Fachbereich Physik, Univ. Oldenburg, D-26111 Oldenburg, Germany), and Armin Kohlrausch (Inst. Perc. Res. (IPO), Eindhoven, The Netherlands)

A multichannel model is discussed which describes effects of spectral and temporal integration in amplitude-modulation detection and masking. Envelope fluctuations within each auditory channel are analyzed with a modulation filterbank. The parameters of the filterbank are the same for all auditory filters and were adjusted to allow the model to account for modulation detection and modulation masking data with narrow-band carriers at a high center frequency. In the detection stage, the outputs of all modulation filters from all excited peripheral channels are combined linearly with optimal weights. To integrate information across time, a "multiple-look" strategy is implemented within the detection stage. Model predictions are compared with literature data from Houtgast [J. Acoust. Soc. Am. **85**, 1676–1680 (1989)]. The following three conditions were reproduced with a deviation of less than 3 dB between experiment and simulation. (1) Masking of test modulations in the range 2 to 64 Hz by a narrow-band masker modulation at 4, 8, or 16 Hz. (2) Modulation masking as a function of the masker-modulation level. (3) Modulation masking as a function of the masker-modulation bandwidth. The results from the simulations further support the hypothesis that amplitude fluctuations are processed by modulation-frequency-selective channels.

4pPP23. Comodulation masking release as a function of masking noise-band temporal envelope similarity in normal hearing and cochlear impaired listeners. Lee Mendoza, Mari L. Schulz, and Richard A. Roberts (Dept. of Speech Pathol. and Audiol., Univ. of South Alabama, UCOM 2000, Mobile, AL 36688)

Thresholds for a pure-tone signal (1000 Hz) were obtained from both normal hearing and hearing-impaired listeners in a variety of masker conditions. Masking stimuli consisted of five Gaussian noise bands, each 20 Hz wide, and centered on 500, 750, 1000, 1250, and 1500 Hz. Two such base stimuli were created. In the first stimulus set, all noise bands had the same temporal envelope (comodulated). In the second set, each noise band was generated independently of the other bands, and thus each had independent temporal envelopes. Additional masking stimuli were generated by combining the comodulated and independent bands at specific comodulated/independent intensity ratios (CIR = 25, 20, 15, 10, and 5 dB), with overall level of the combined noise bands held constant. The result of increasing CIR was a progressive increase in the similarity of temporal envelopes of the noise bands masking the signal. Compared to threshold for the pure-tone signal in independent bands of noise, threshold steadily decreased as the CIR increased for normal hearing listeners. Cochlear-impaired subjects also showed decreased threshold with increasing CIR; however, the improvement was seen to plateau at relatively low CIRs. [Work supported by DRF and USARC.]

4pPP24. Discrimination of harmonic- and log-spaced profiles and of static and dynamic profiles by good and poor profile listeners. Ward R. Drennan and Charles S. Watson (Dept. of Speech and Hear. Sci., Indiana Univ., Bloomington, IN 47405)

Most profile experiments have employed static profiles with logarithmic spacing. Many naturally occurring sounds have harmonic spacing and vary dynamically in time. Watson and Drennan [J. Acoust. Soc. Am. **97**, 3272(A) (1995)] examined profile discrimination using both static and frequency-glide profiles with harmonic and logarithmic component spacing. Subjects detected an intensity increment in the middle component of 11-component, 400-ms profiles with a frequency range of 200–2200 Hz. Differences among the seven subjects were considerably larger than differences among the types of profiles, confirming earlier observations of a large range of abilities to discriminate profiles. Another experiment was therefore conducted to estimate the distribution of profile discrimination abilities for normal-hearing listeners. Forty-six subjects were screened using static-log profiles. The distribution of thresholds was roughly normal with a range of -2 to -26 dB (signal level relative to component level) and an s.d. of 4.8 dB. No dichotomy in profile discrimination ability was found. Subjects were selected from each tail of the distribution and tested using the static-log, static-harmonic, dynamic-log, and dynamic-harmonic profiles. The order of presentation of conditions significantly affected the results; however, whatever the order, static profiles yielded lower thresholds than the frequency-glide profiles. [Work supported by NIH/NIDCD and AFOSR.]

4pPP25. Distinctiveness and serial position effects in tonal sequences: Combining DDT and PTD. Aimee M. Surprenant (Dept. Psychol. Sciences, Purdue Univ., W. Lafayette, IN 47907)

The proportion-of-the-total duration rule (PTD) [Kidd and Watson, J. Acoust. Soc. Am. **92**, 3109–3118 (1992)] states that the detectability of a change in a component of a tonal sequence can be predicted by the duration of the changed component relative to the sequence as a whole. A similar idea has been used in dimensional distinctiveness theory (DDT) [Neath, Mem. Cognit. **21**, 689-698 (1993)] to account for primacy, recency, and other serial position effects in memory. An item will be remembered if it is more distinct along some dimension relative to possible competitors. These experiments explore the relation between DDT and PTD by examining the effect of inter-stimulus interval (ISI) on the detection of a change in one tone of a tonal sequence for each serial position in the sequence. Results show that, with increasing ISI, performance on the first items increases whereas performance on the final items decreases, as predicted by DDT. In addition, the interaction of PTD and ISI was explored for each serial position. This research combines theories proposed in the psychophysical and memory areas and suggests that a comprehensive principle based on relative distinctiveness can account for both perceptual and memory effects.

4pPP26. Temporal integration as a function of masker bandwidth. Andrew J. Oxenham (Inst. for Percept. Res. (IPO), P.O. Box 513, 5600 MB Eindhoven, The Netherlands)

Thresholds were measured for a 6-kHz sinusoid, temporally centered in a 500-ms masker which was either a bandpass Gaussian noise (20 dB SPL spectrum level) or a 6-kHz sinusoid (40 dB SPL). A notched noise centered on 6 kHz prevented the use of off-frequency cues. The signal, gated with 2-ms ramps, ranged in half-amplitude duration from 2 to 300 ms. The noise bandwidth was arithmetically centered on 6 kHz and was varied from 60 Hz to 12 kHz. For masker bandwidths below 300 Hz, the slope of integration for signal durations between 2 and 20 ms decreased with decreasing masker bandwidth. For the tonal masker, increasing signal duration from 2 to 20 ms had no effect on threshold. These results cannot be accounted for by lowpass-filter or temporal-window models of temporal integration or resolution. Instead, it is proposed that the auditory system performs a spectral analysis of the stimulus envelope, so that the rapid fluctuations (high modulation frequencies) introduced by gating the signal can be used as a cue for brief signals in narrowband noise and tones. For broadband maskers, this cue is not available due to the masker's inherent rapid envelope fluctuations. [Work supported by the Wellcome Trust.]

4pPP27. Sinusoidal amplitude modulation thresholds as a function of carrier frequency and level.

Ralf Fassel and Armin Kohlrausch (Inst. for Perception Res., P.O. Box 513, NL-5600 MB Eindhoven, The Netherlands)

Modulation detection thresholds for sinusoidal carriers were obtained for a wide range of modulation rates (10–1600 Hz) as a function of carrier frequency (1, 3, 5, 8, and 10 kHz) and carrier level (30, 45, 60, and 75 dB SPL). At low modulation rates, between 10 and about 100 Hz, thresholds were roughly constant. For higher modulation rates, thresholds were dependent on carrier frequency. For the lowest carrier frequency (1 kHz), the modulation sidebands were already spectrally resolved at a modulation rate of 100 Hz and thus thresholds decreased with increasing modulation rate. For the higher carrier frequencies, the sidebands were resolved only at higher modulation rates, due to the increasing auditory-filter bandwidth. In these cases, thresholds initially increased with increasing modulation rate with a slope of about 8 dB/oct. The threshold curves show a different shape than those obtained with broadband noise carriers. In general, thresholds decreased with increasing carrier level at any given carrier frequency up to at least 60 dB SPL. For one subject a saturation of thresholds at medium carrier levels was observed. At very low carrier levels of 20 dB SL, thresholds tended to increase with increasing modulation rate already below 100 Hz.

4pPP28. Across-channel processes in frequency modulation detection.

Shigeto Furukawa and Brian C. J. Moore (Dept. of Experimental Psych., Univ. of Cambridge, Downing St., Cambridge CB2 3EB, UK)

This study examined whether the detection of frequency modulation (FM) on two carriers depends on the coherence of the FM across carriers. Psychometric functions were measured for detecting sinusoidal FM of carriers with frequencies 1100 and 2000 Hz. The modulators for the two carriers were either in phase (coherent) or in anti-phase (incoherent). The modulation rate was either 2.5, 5, or 10 Hz. One or more cycles of modulation were used. The modulation of each carrier was equally detectable, as determined in a preliminary experiment. A continuous pink noise background was used to mask the outputs of auditory filters tuned between the two carrier frequencies. Detectability was better for coherent FM than for incoherent FM. The effect of FM coherence was greatest at the lowest modulation rate, possibly indicating that phase locking plays a role [B. C. J. Moore and A. Sek, J. Acoust. Soc. Am. **97**, 2468–2478 (1995)]. The detectability of the coherent FM was well above the value predicted on the assumption that information from the two carrier frequencies was processed independently and combined optimally. These results imply the existence of one or more mechanisms sensitive to FM coherence. [Work supported by the MRC(UK), the British Council, and an ORS award.]

4pPP29. Within and across channel processes contributing to comodulation detection differences.

Stephen J. Borrill and Brian C. J. Moore (Dept. of Experimental Psych., Univ. of Cambridge, Downing St., Cambridge CB2 3EB, UK)

The threshold for detection of a narrow-band noise signal was determined in the presence of a masker consisting of two synchronously gated 20-Hz-wide bands of noise with a spectrum level of 65 dB which were comodulated. The maskers were spaced by ΔF Hz above and below the signal frequency (1500 Hz). A low-pass noise was used to mask any combination products. Three conditions were tested: signal and masker envelopes correlated (C), signal and masker envelopes uncorrelated (U), or sinusoidal signal of the same overall level (S). ΔF ranged from 200 to 1400 Hz. Masked thresholds for the U and S conditions were essentially identical for all ΔF. Thresholds were higher in the C condition, thus showing a comodulation detection difference (CDD). The CDD was greatest for ΔF between 400 and 600 Hz. A second set of conditions was used in which either one, both, or none of the masking bands was comodulated with the signal. This was done for three different masker spectrum levels at a ΔF of 600 Hz. The results suggest that the CDD seen in the first experiment was mainly due to the upward spread of masking from the lower band and not to an across-channel grouping effect.

4pPP30. Amplitude-modulation depth discrimination of a sinusoidal carrier.

Jungmee Lee and Sid P. Bacon (Psychoacoustics Lab., Dept. of Speech and Hearing Sci., Arizona State Univ., Tempe, AZ 85287-1908)

Discrimination of the change in depth of sinusoidal amplitude modulation was investigated for a 4000-Hz carrier. The just noticeable change in the modulation depth (Δm) was measured as a function of (1) standard modulation depth (m = 0.1, 0.18, or 0.3), (2) modulation rate (f_m = 10, 20, 40, or 80 Hz), and (3) stimulus duration (T=25, 50, 100, 200, 400, or 800 ms). For modulation rates less than 80 Hz, threshold (Δm) was higher at a standard depth of 0.3 than at the other standard depths. When f_m = 80 Hz, the threshold was almost the same across different standard modulation depths. For all standard depths and modulation rates, the threshold decreased by more than a factor of 2 as stimulus duration increased to a certain T (critical duration). For durations longer than the critical duration, the threshold decreased only slightly or remained constant. The critical duration corresponded to about four cycles of modulation. Psychometric functions were measured for different stimulus durations. The data were evaluated in terms of a multiple-looks model. [Work supported by NIDCD.]

4pPP31. Detection of tones in modulated noise: Effects of masker level and masker depth.

Sid P. Bacon, Jungmee Lee, Daniel N. Peterson, and Dawne Rainey (Psychoacoustics Lab., Dept. of Speech and Hearing Sci., Arizona State Univ., Tempe, AZ 85287-1908)

It is possible to estimate temporal resolution at discrete spectral locations by subtracting the masked threshold produced by a modulated masker from that produced by an unmodulated masker (the difference is referred to as the modulated-unmodulated difference, or MUD). This paradigm may be especially useful for measuring temporal resolution in subjects with hearing loss, provided that the MUD is independent of level. The purpose of the present study was to examine the MUD as a function of masker level at several signal frequencies. In the first experiment, the sinusoidally amplitude-modulated masker had a depth (m) of 1.0. The MUD increased by as much as 15 dB as the spectrum level of the masker increased from 0 to 40 dB SPL. In the second experiment, the modulated masker had a depth of 0.75 or 1.0. When the masker depth was 1.0, the MUD increased with increasing masker level, as in experiment one. When it was 0.75, however, the MUD — though reduced — was essentially independent of masker level. These results suggest that a masker depth of 0.75 may be used to compare temporal resolution between normal-hearing and hearing-impaired subjects without being complicated by effects of masker level. [Work supported by NIDCD.]

4pPP32. Effects of noise on the hearing system.

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This paper provides an overview of effects of noise on the hearing system. Animal research has shown that excessive noise exposure results in decrease of blood flow in stria vascularis, alteration in permeability of ions in reticular lamina, swelling/rupture of hair cells, disarrangement or loss of stereocilia, broken tip links and side links between the stereocilia, swelling of afferent dentrides, rupture of the organ of Corti, decrease in tectorial membrane thickness, and increase in its compliance, etc. After the exposure, the stereocilia may become a fanlike structure or fuse together to form a giant stereocilia. In a severely damaged cochlea, the hair cells may